THE USE OF TRAP TREES IN THE CONTROL OF

THE WESTERN PINE BEETLE.

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O U T L I N E

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INTRODUCTION

Trap trees have long been considered as a method of controlling in barkbeetle outbreaks in European and American forests. This method is based upon the well established habits of certain scolytid beetles to attack freshly felled, windblown, or girdled trees in preference to standing timber. While this method has been employed to a considerable extent in European countries its use in control against Dendroctonus beetles in the Western United States has been limited to a few projects mainly concerned with the control of the western pine beetle, (Dendroctonus brevicomis Lec.)

In the attack of barkbeetles upon the cambium of healthy living trees, the natural sap flow offers considerable resistance, which results in the formation of the "pitch tubes" upon the outer surface of the bark. In the case of Dendroctonus attacks, the insects therefore must attack in sufficient numbers to overcome this sap resistance or else the attacking adults are drowned out and the broods fail to develop.

The trap tree differs essentially from the standing tree in that the natural sap flow is checked and resistance is lacking. A few beetles can successfully attack and develop broods in a felled tree whereas several thousand would be required to successfully attack and overcome the resistance

of a healthy tree of the same size. In studies of the brood development of the western pine beetle carried out in California and Oregon it was found that the number of attacks per square foot of infested bark in windfalls or felled logs in logging slash varied considerably and was from 50 to 70 percent less than the average which occurred in the bark of standing infested trees. The subsequent emergence of broods was usually less than 50% of the normal in standing trees. The sap condition of felled trees is apparently less favorable for brood development than that of standing trees killed by the beetles.

The use of girdled or felled trap trees in the control of the western pine beetle was first suggested by Dr. A. D. Hopkins.*

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* Bull. 83, Part I. Bureau Entomology - U. S. Department of Agriculture.

"Under certain conditions, therefore, as in the case of absence of logging operations and where only a few scattered trees are infested - it may be desirable as a means of maintaining control, to provide a few trap trees to attract the first generation. This can be done by girdling two or three inferior trees to the heartwood or by felling them in June. Then if they become infested with this beetle, the bark should be removed from the main trunk and burned by the middle of August. Trap trees to attract the second generation should be prepared in August and September and barked before the first of the following May. Usually an average of one to three

trees to the acre should be sufficient for this purpose. However, the number will depend largely upon the prevalence of the insect."

Theoretically there are obvious advantages in the use of trap trees, providing they can be used to attract beetles to such an extent that the flying adults will be drawn away from attacks upon standing green trees. It is possible to select for trap trees, suppressed, decadent, defective or otherwise inferior trees whose removal will be of general benefit to the forest. Trap trees can also be used to localize the infestation at accessible points which is of decided advantage in the conduct of control work. Still another factor in the use of trap trees is the selection of trees in the smaller diameter classes which compared with the larger standing trees usually attacked by the beetles contain a relatively small volume of merchantable lumber in proportion to the amount of bark surface infested. By trapping the infestation in smaller trees, the loss of timber sustained will be considerably less than if the beetles select of their own accord, standing mature trees.

During the period from 1918 to 1922 a series of experiments were carried out to determine the effectiveness of trap trees in control of western pine beetle infestation. The experiments were carried out at several localities in southern Oregon, northern California and the southern Sierra Nevada region.

TYPE OF TRAP TREE ATTRACTIVE TO BEETLES.

Girdled Trees:

Girdled trees were found to attract beetles only after a consid-

erable interval of time. One tree which was sap-girdled in 1916, i.e. the bark peeled from the sapwood on a strip about three feet wide entirely around the bole, remained green and up to 1920 had not been attacked.

Trees girdled to the heartwood were eventually attacked but in the case of two trees girdled at Northfork, Cal. in April 1920, attack did not occur until the fall of 1922. On the whole the use of girdled trees was not thoroughly tested out as it was soon found that the attraction of felled trees was much more reliable. In control measures the tree must be felled in any case to treat the broods so that there is a direct saving in falling the trees at the time they are selected for traps.

Felled Trees:

Experiments with this method soon demonstrated that trees felled during the period from April 15, to September 15, were successful in drawing the attack in from 4 to 25 days after felling. In the various series of trees which were used in these tests only a very small percent failed to attract breeds within a short period after felling. It was found, however, that during the months of May, June, July, August and September, no attacks would occur in any part of the log which was exposed directly to the sun during the middle of the day. The beetles, however, would attack the under-side of exposed logs, or the entire surface of logs which were shaded. This habit apparently has some connection with the fact that during the summer months solar heat is sufficient to kill broods in infested bark on the upper surface of exposed logs.

In order to make trap trees attractive during the summer season it was found necessary to shade them either by falling them in situations shaded by other trees or covering them with tops, limbs and brush. During the early spring months, however, and after the 15th of September trap logs which were directly exposed to the sun were the more attractive and the beetles were slow to attack logs which were covered or in cold shaded situations.

DISTANCE OF ATTRACTION TO TRAPS

The location of trap trees on an area should depend upon the distance from which beetles can be attracted from the surrounding timber. It was found that where traps were put out in the main timber belt they were soon attacked, but as infested trees could always be found within a distance of one fourth to half a mile, no great distance of flight was established. In order to obtain some evidence as to the maximum distance of attraction, an effort was made to locate trees for traps along the edge or outside of the main timber belt where the distance covered by the flight of the beetles could be positively established. One of these was found on the Sequoia National Park where the nearest infested tree was distant about 1.2 miles. Another case was located in the Rogue River Valley, Oregon where the distance to the nearest infested tree was above two miles. Both trees were successfully attacked by the western pine beetle and associated insects. In the case of the tree in the Rogue River Valley the beetles crossed an open non-forested area for a distance of one mile before reaching the trap tree. These records

indicate that the attraction of the trap log is a strong one and may be effective for distances of one to two miles.

USE OF TRAP TREES ON CONTROL PROJECTS

Since trap trees are effective only during the period of flight of the beetles, it is necessary that they be used in control operations during the summer season. For this reason the use of traps in control of the western pine beetle was not considered until the idea of summer control work was taken up. This was first attempted on the Sequoia National Park after the discovery of the solar heat method of treating infested bark made summer control work feasible.

In 1921 and 1922 trap trees were used on the Antelope Control Project in Northern California. In the San Joaquin control project where summer work and maintenance control were tested out, trap trees were tried for three years and their effectiveness in attracting beetles and effect upon the surrounding infestation studied in some detail.

Sequoia National Park:

This first work was carried out during the summer of 1919. The basis of these studies consisted of a total of 23 yellow pine with a volume of 50,000 board feet and 37 sugar pine with a volume of 165,630 board feet, located in the Marble Fork basin an area of about 6000 acres. The yellow pine was the only host in which the western pine beetle was trapped.

The traps selected consisted of windfalls of the preceding winter, top killed, suppressed, decadent, fire injured trees and trees felled in road

work. These trees were located close to roads and did not average more than three or four to the mile. Periodic records were kept to determine the interval between felling and attack and subsequent development of broods.

Attacks in all of the western pine beetle trees were uniformily successful. During the season the maximum period between felling and attack was 18 days the minimum 4, and the general average 10.5 days. In general the period between felling and attack was somewhat longer during May and June and shorter during the mid-summer period in July and August. Toward the close of the season in September and October the period again became longer. Trees felled after the 20th of October did not develop an attack until the following spring.

The result of these studies indicated that trap trees could be used in summer control work to draw broods of beetles, but the ultimate effect of their use in controlling the infestation by trapping it in selected trees and preventing attacks in standing timber could not be determined by these tests.

Antelope Project:

This control project, a private enterprise, which was carried out on a forty thousand acre tract in Northern California in 1921 and 1922 included the treatment of over 6000 infested trees containing about five and one half million board feet of timber. In addition, 655 trap trees containing 547,000 board feet were cut during the summer seasons and subsequently treated as an auxillary measure of control. Mr. J. E. Patterson of

the Bureau of Entomology, who directed the technical features of this work in an advisory capacity, has summarized the results as follows:

"Two series of traps were used in 1921. One of these series was felled in June and one in September.

Only one series was used in 1922 and this one was felled in June.

The number of trees felled in each series was based on an estimate of the amount of the first seasonal infestation following the last intensive work. This number was approximately 12% of the estimated recurring infestation.

Results: All trap trees felled were more or less heavily attacked soon after they were placed. In the trees felled in June the broods developed rapidly and were treated during the latter part of July and in August. These trees peeled easily and were treated with minimum of labor and time. They were no doubt successful in drawing a large amount of infestation away from the standing timber.

The trees felled in September 1921 were not so successful as the broods developed slowly and overwintered in the trees. They were treated with a great deal of difficulty the next spring. A great amount of labor and time was required in treating these trees as the bark held tenaciously to the logs and was so saturated with moisture that it did not burn well.

As a successful form of control the method is somewhat doubtful in efficiency. The trees were fairly heavily attacked and no doubt drew and localized a large amount of infestation. However, there was a tendency to create group infestations in standing trees adjacent to the traps. This was one noticeable effect of the method on this project; a number of instances were noted where these groups amounted to 4 or 5 standing trees per group."

USE OF TRAP TREES IN EXPERIMENTAL MAINTENANCE CONTROL ON THE SAN JOAQUIN PROJECT.

The purpose of this project was to carry on control operations against an endemic infestation with the idea of attacking increasing infestations in their incipient stages and reducing losses to the lowest point practicable. It was initiated in 1920 on a tract of 130,000 acres of the

Sierra National Forest. The use of trap trees during the summer season figured in the early plans for the project. While both the western pine beetle and the mountain pine beetle constituted the primary infestation on the area the former was considered to be of primary importance. Only yellow pine trees, cut to trap the western pine beetle, were used in the trap tree work.

Preliminary Tests:

During the seasons of 1920 and 1921 trap trees were used throughout the season from June 1 to September 30. Aside from windfalls, trees cut in road construction work and the green butts and tops of infested trees cut in control work, selected standing green trees also were cut. These were selected primarily as top killed, suppressed, defective or fire-injured trees, the removal of which would be of some benefit to the forest. An effort was also made to select trees only in diameter classes below 30 inches D.B.H. so that the volume of merchantable timber would be as small as possible in proportion to the amount of bark surface available for trap material.

During these two seasons a total of 371 yellow pine with a volume of 345,790 board feet were cut and treated. These traps were distributed at accessible points usually along roadways. They did not average more than four to the mile and for the entire area not more than five to the section. In nearly all cases attacks were attracted and the broods treated by sun-curing or burning before emergence.

Toward the close of the 1921 season the infestation started to increase. It was apparent that trap trees were having but little effect in holding the infestation and that on areas where traps had been placed the infestation in standing trees was just as aggressive as on areas where no traps had been placed. Either the traps were not in sufficient quantity to hold the beetles or they were futile as a method of control.

It was decided, therefore, in view of these results to determine by a quantitative test the capacity of trap trees to absorb beetles to the extent of keeping them out of standing trees.

The Trap Tree Circle:

An area known as the Summit Meadow Circle representative of the normally infested site and type conditions was selected. A line of trap trees, spaced approximately at the distance of 20 to the mile was laid down in the form of a circle .5 of a mile in diameter. Starting in the spring of 1924 the area within this circle was intensively cruised and all infested and ~~doubtful~~ trees and those outbreaks of infestation were felled and treated. The traps then were laid out so that they surrounded a clean area. It was considered that under these conditions all beetles coming to the traps would be drawn from the area outside of this circle. Any trees attacked within the circle would be infested by beetles which had crossed the line of traps. Even if it were possible that all of the infestation had not been found and treated, the circle of trap trees should contain enough freshly felled material within a distance of less than ½ of a mile to absorb any beetles left within the circle. Subsequent attacks within the area of the circle would demonstrate that the beetles had disregarded the attraction

of the trap trees to attack standing trees.

On June 9, 1924, a ring of 31 trap trees was laid down to absorb attacks of the first summer generation. The second ring of 30 traps was laid down on August 7 for the second generation and a third series of 23 trees on October 7 to take up any late attacks of the overwintering generation. In the meantime the area within the circle was closely cruised every three weeks and infested trees which developed were treated.

The Trap Tree Line:

In addition to this experiment a trap line approximately 6 miles in length was laid out with the trees spaced six or eight to the mile. The purpose of this trap line was to place out more trap trees than had been used in previous control work and to spread them out instead of concentrating them as in the case of the trap tree circle. The results should show whether traps scattered out in this way would absorb more beetles than traps concentrated on a small area and whether they would have any appreciable effect upon the infestation in the adjoining timber.

Method of Recording Infestation:

In from four to six weeks after these series of traps were cut and prepared they were peeled and the bark suncured or burned. In order to form some estimate of the success of the traps in attracting the beetles it was necessary to keep a record of the species of insects drawn to them, and the percent of bark surface infested by each species, together with an estimate of the degree of attack, whether heavy or light, based upon the number of beetles attacking per square foot of bark. This latter was arrived at by the

Entomological Ranger in charge of the work by an estimate. Bark which was fully attacked was rated at 10, less heavily attacked 9, and so on down to 1, which represented only traces of the species. Each trap was finally rated according to the percent of bark surface attacked and the degree of attack, i.e. where 100% of the susceptible bark surface was attacked by the western pine beetle and contained a maximum attack, estimated at 10, the tree was given the maximum rating of 1000. If 60% of the bark surface was infested and the degree of attack estimated at 8, the tree was given a rating of 480. Each tree was rated in this manner for the two more important species, D brevicomis and Ips oregonis which figured in the attacks. While not strictly accurate it was the only ready basis for comparison, and represented so far as the estimator could determine, the success of the individual traps in attracting beetles.

Character of Infestation in the Traps:

The character of the infestation attracted to the traps is shown on Table I. Summarized, this shows the following:

Trap Tree Circle -

Series cut - June 7: All were infested by the western pine beetle but with relatively light broods. Light broods of Ips infestation occurred in 29% of them and flat head infestation in 9.7%. Broods developed to pupae by August 1.

Series cut - August 7: Thirteen percent were not attacked by insects. D. brevicomis occurred in eightysix percent and the broods were relatively heavier than in the series cut in June. Ips developed with light broods in thirteen percent. No flatheads were attracted. Broods developed to pupae by October 5.

Series cut - October 7, 1924: While a few of these were attacked in the fall, most of them remained green through the winter and were not attacked until the spring of 1923. Over eight percent remained green through the following

summer and were not attacked by insects at all. D. brevicomis attacked 87% and Ips 69%, both with light broods. These broods developed full grown larvae by the 10th of June.

Trap Line-

Series Cut - June 14: Eightytwo percent were attacked by D. brevicomis with strong broods. There were no Ips attacks and 25% were attacked by the flathead. Five percent remained green.

Series Cut - August 18: Only 33% developed attacks in time to be treated in 1922. The remainder carried over green and were attacked the next spring. Ninetyfive percent were attacked by D. brevicomis with strong broods. No flatheads were noted but 35% were attacked by Ips oregonis in the spring period. 4.7% remained green.

Series Cut - October 10, 1922: All trees carried over until the spring of 1922 were attacked then. 81.8% were attacked by D. brevicomis but with relatively light broods. Ips oregonis attacked 45 percent with light broods. 18% remained green and were not attacked by insects.

Altogether the trees in the trap line were the more successful in attracting strong attacks of the western pine beetles. Trees cut in June and August were the more successful than those cut in October both in the trap tree circle and on the trap line. Trees cut in Oct. drew considerable mixed infestation and were not heavily infested.

Proportion of Ips beetles in Traps: Ips beetles were abundant in the spring or early summer. The greater part of the Ips was graded below 200, i. e., it constituted less than 20% of the infestation in the traps.

Effect of Trap Trees on the Surrounding Infestation:

The outstanding feature of the infestation during the season of 1922 while this experiment was being carried on was an increase throughout the region both on areas that were left untreated and also where control work was being carried on. On the units surrounding the trap tree experiment the number of standing yellow pine attacked increased from 374 in 1921 to 610 in 1922. The increase in volume was from 595,650 board feet to 937,150 board feet or 57%.

SUMMARY OF RECORDS OF INFESTATION IN YELLOW PINE TRAP TREES - 1922.

	Summit Meadow Circle			Logan - Meadow Trap Line		
	3eries cut June 9	Series cut Aug. 7	Series cut Oct. 7.	Series cut: June 14-24	Series cut: Aug. 18-29	Series cut Oct. 10
Total No. Trees	31	30	23	39	42	11
Percent of Trees Attacked by D. brevicomis	100. %	86.4%	87. %	82. %	95. %	81.8%
" " " " " Ips oregonis	29. %	13.3%	69.5%	-	35. %	45.4%
" " " " " Melanophila Sp.	9.7%	-	-	25.6%	-	-
" " " " " D. monticolae	3.2%	3.3%	-	-	-	-
" " " " " D. brevicomis & Ips oregonis	29.%	13.3%	65.2%	-	30.9%	45.4%
" " " " " D. brevicomis only	64.5%	73.3%	13. %	64.1%	64.2%	27.2%
" " " " " Ips oregonis only	-	-	4.3%	-	4.7%	-
" " " Not Attacked	-	13.3%	8.6%	5.1%	4.7%	18.1%

Degree of Attack	D.b.	Ips	D.b.	Ips	D.b.	Ips	D.b.	Ips	D.b.	Ips	D. b.	Ips
100	9.7%		20. %	3.3%			61.5%		54.7%		18.1%	
90	9.7%		16. %		4.3%		5.1%	2.5%	2.3%			
80	19.4%		13.3%		4.3%		7.3%		11.9%			
70	22.6%		3.3%		4.3%				4.7%	4.7%		
60	16. %		6.6%		4.3%	4.3%		5.1%	14.2%	2.3%	9. %	9. %
50	3.2%		6.6%		4.3%	4.3%						
40	3.2%				34.8%	4.3%		5.1%	7.1%	4.7%	36.3%	
30	9.7%				4.3%	8.6%		5.1%	4.7%			9. %
20		10%		6.6%	8.6%	13. %				11.9%	18.1%	9. %
10	6.4%	16%	10. %	3.3%	17.4%	30.4	5.1%	2.5%		11.9%		18.1%

Results Within the Summit Meadow Trap Tree Circle:

One large 60 inch yellow pine was found within the ring of trap trees on July 22. The development of the broods at that time indicated that the tree may have been attacked around June 15, about the time or shortly after the date when the first line of trap trees were cut. During the season six additional standing yellow pine were attacked and killed by beetles within the circle. Two of these were attacked between August 15 and September 1, three between September 1, and September 15, and one between September 15 and 30. The furtherest advance inside the area was about ½ mile from the line of traps. During all of this period fresh trap tree material was on the ground which the beetles could have attacked if preferable. Undoubtedly a certain number of the beetles preferred suitable standing trees to the traps, and the availability of the trap material did not keep them from attacking such trees.

During 1921 when practically no traps were available the insects killed 10 trees with a volume of 15,370 board feet within the area of trap tree circle. In 1922 with a concentration of traps around the area, 7 trees were killed with a volume of 18,590 board feet. This was less than the general increase in the surrounding area so apparently the trap trees were of some effect in holding down the infestation but certainly not to an extent to make their use profitable.

Progress of Infestation Within One Mile of Trap Trees:

Summit Meadow Trap Tree Circle-

A total of 84 trees with a volume of 25,590 board feet were felled

as traps on this area during the season of 1922.

Within the zone extending one half mile from the ring of trap trees, 21 trees with a volume of 32,100 board feet were killed by beetles in 1921 when no trap tree material was available. On the same area 37 trees with a volume of 51,220 board feet were killed during 1922, the period while the attraction of the trap trees was in effect.

This represents an increase of 59% or about the same as that in the surrounding units.

In the zone beyond this, between one half mile and a mile distant from the ring of trap trees, 47 trees with a volume of 81,640 board feet were killed in 1921 while 72 trees with a volume of 123,220 board feet were killed in 1922, an increase of 52%.

On the whole, the course of the infestation within a mile of the trap trees did not differ appreciably from that of the surrounding units.

Logan Meadow Trap Line-

During the season of 1922, 91 trees with a volume of 16,000 board feet were felled for trap tree material.

Within the zone extending one half mile on either side of the traps, 69 trees with a volume of 96,870 board feet were attacked in 1921 while 101 trees with a volume of 132,750 board feet were attacked in 1922, an increase of 37% during the period while the attraction of the traps was in effect.

Within the zone between half a mile and one mile distant from the traps, 96 trees with a volume of 48,200 board feet were attacked in 1921 while 33 trees with a volume of 60,080 board feet were attacked in 1922, an increase of 25%.

In both of the zones the increase was less than in the surrounding units. It is apparent, however, that the 16,000 board feet of trap tree material could have been of but little influence in holding down this increase. It is more than likely due to local shifting in the flight of beetles throughout the area.

In this case, however, there was some evidence that the attraction did serve to localize attacks in standing trees in vicinity of the traps. Several groups of 4 trees and one group of 14 trees developed in vicinity of the traps which is reflected in the larger increase in the half mile zone.

General Results:

The general result of these tests is that trap material, even if available, will not keep the beetles from attacking standing trees that are especially attractive to them. They also show that while a large percent of the beetles prefer to attack the traps, this attraction is not sufficient to prevent an increase of the infestation in standing trees in their vicinity where only a relatively small volume of trap tree material is made available. The cutting of a very large quantity of trap tree material such as that created by a logging operation might prevent a general increase of the infestation, but the use of trap tree material on such a scale in protective work would be altogether impracticable unless the timber cut can be promptly utilized.

INFLUENCE OF SLASH AS TRAP MATERIAL.

The great amount of freshly felled logs in a logging operation creates a great quantity of trap material on a local area. That the beetles

are frequently attracted to this material is a matter of common observation, but the attacks are widely scattered and heavy or normal broods rarely develop. It also is a matter of record that the beetles do occasionally attack standing trees in the vicinity of logging operations regardless of the vast quantity of trap material available. However, a very large percent of the beetles are drawn to the logs and where these are soon removed from the woods and taken a considerable distance to the mill, or disposed of so as to kill the broods, such as floating in water or/where the logs are promptly milled and the slabs burned, the operation undoubtedly contributes to a considerable reduction of the beetle population of the area.

Mr. J. M. Patterson during the period from 1920 to 1923 made a detailed study of the infestation developing in the slash created by cutting of a right of way in Southern Oregon. This development consisted of cutting a strip 100 feet wide and 22 miles long through a yellow pine forest. The logs were cut into lengths and left on the ground beside the right of way. At the time there was a normal infestation of the western pine beetle in the surrounding area and the amount of trap material was far in excess of that needed to absorb all of the infestation in the adjoining forest. The result was that while 97% of the logs attracted beetles, very few of them were heavily attacked, the beetles apparently scattering their attacks throughout the material. The mortality of the broods developing from these attacks was excessive, averaging around 74%. This apparently was induced by an excessive moisture condition, known as "sour sap" which developed in practically every tree. The infestation

in the adjacent forest following emergence from the trap trees was not materially increased over that in which existed in the same area prior to the slash. On the whole the sudden creation of this excess of trap material apparently had but very little influence upon the course of the western pine beetle infestation in the surrounding areas.

SUMMARY

1. The western pine beetle will attack and develop broods in girdled and freshly felled yellow pine trees.

2. Due to absence of sap resistence it is not essential that beetles attack in numbers sufficient to fill a living tree - as a result, attacks may be scattering and the brood development much lighter than in standing trees.

3. Felled yellow pine trees will more readily draw the attacks of beetles than girdled trees. Felled trees will draw attacks in from 4 to 25 days during the period from June 1, to September 30. Even trees girdled through the heartwood may stand two seasons before they are finally attacked by the beetles.

4. The attractiveness of the felled traps to broods of the western pine beetle depends upon exact moisture conditions of the sap or other factors influenced by the period when tree is cut and exposure of log to solar heat. During months of June, July and August it is necessary to shade upperside of log in order to induce attacks.

5. Trap trees which are attractive to the western pine beetle will also draw the attacks of Ips beetles, flatheads (Melanophila spp.) and the mountain pine beetle. In the San Joaquin project the western pine beetle broods constituted more than 75% of the infestation drawn to the traps.

6. The capacity of trap trees to prevent attacks in standing green trees by attracting beetles in flight is limited. The attraction of certain standing trees is such that beetles will attack them regardless of the amount of trap material in the vicinity. Even the abundance of trap material in logging operations is not sufficient to prevent occasional attacks on standing trees in the vicinity.

7. Experiments indicate that trap trees on a limited scale will not prevent an increase of the infestation either in their immediate vicinity or in zones one mile distant. Whether or not the creation of an abundance of trap material such as furnished by a logging operation will prevent increase has not been determined, but it is evident that unless the timber can be utilized, the effort to control infestations by a promiscuous cutting of trap material would be highly impracticable.

8. The cutting of trap trees as a method of control is questionable and of doubtful benefit. Where windfalls, or trees cut in construction work are found to be infested while control work is in progress, treatment of such trees may be advisable as some beetles are destroyed and no timber values sacrificed.